Compressed Air

A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

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We invite correspondence from engineers, contractors, inventors and others interested in compressed air.

All communications should be addressed to COMPRESSED AIR, 26 Cortlandt St., New York.

Those who fail to receive papers promptly will please notify us at once.

MARCH, 1896.

COMPRESSED AIR.

The appearance of this little magazine, published for the purpose of disseminating information regarding this important branch of science, will, we trust, be received with gratification. Thus far the subject has been treated in only a fragmentary way. An occasional book, lecture, essay or articles in trade papers have been the extent of its promotion.

Only a small amount of literature on this subject has been separated from trade interests, and the information given has been chiefly of value when examining the relative qualities of the manufacturer's product.

Compressed air, as a useful power, demands attention. Its scope of usefulness is each day widening, and its possibilities are beyond conjecture. The era of Compressed Air is even now upon us, and its claims must be placed beside electricity and other great scientific auxiliaries that have been developed in this age of progress.

We believe that the development of the science of compressed air has suffered for want of publicity. Discussion, controversy, advertising—all lead to a better knowledge of the subject and point the way to larger fields of usefulness.

It is this condition which COMPRESSED AIR seeks to bring about.

We enter upon the work with enthusiasm commensurate with the vastness of the subject and are hopeful of success.

COMPRESSED AIR greets you.

AIR POWER.

The power of air is shown in the cyclone and whirlwind which have in a few moments of time uprooted the stanchest trees, requiring a power that has been estimated to be beyond any that is within the control of man.

The power of air is shown when the sail of the ship is made to drive thousands and tens of thousands of tons weight through the waves of the sea. What power has done greater service to mankind than this? Air power has been the means by which continents have been discovered and populated. It has done more for civilization than Christianity. It has been the means by which the world has been conquered and subdued. It is the first cause leading to the wealth of nations.

The power of air when applied to the rock drill is shown in the building of great tunnels and in the development of mines. The "Hoosac," "Sutro" and New York Aqueduct Tunnels would have been almost impossible but for compressed air. The great piers of the Brooklyn Bridge required compressed air in the caissons to enable them to reach solid rock foundations. By no other means known to engineers could

this bridge have been built; and so with most of the great bridges and tunnels of the world.

The power of air is shown in the blast furnace producing iron and steel, the most useful metals known to mankind.

Air power is shown in the brakes on the train, when hundreds of tons, moving fifty miles an hour, are brought to a standstill within a few hundred feet. Think of the power required to do this! The little air compressor perched on the side of the great engine brings all this about. Think of the lives that have been saved by the air brake!

The power of air is shown in the gas engine which uses a combination of air and gas as an explosive mixture of great force. The hot air engine produces power with air alone.

Air power is used to move railroad switches and signals more than twenty miles from the source of supply. Air hoists, air jacks and air lifts are valuable auxiliaries. Water is raised from subterranean sources and delivered to the reservoir by compressed air. The power of air drives the shell from the dynamite gun. Granite is cut and carved by the pneumatic tool. Air power is used to raise sunken ships. The fall of water converted into air power is used miles away to produce useful results.

Air power in shops is used to clean castings, for punching, caulking, tapping, drilling, reaming, chipping, riveting.

Painting is done by air power. Each month brings forth a new illustration of the power of air. We need not, therefore, offer any apologies for this little magazine which seeks to aid in throwing light upon this big subject.

WHAT would railways be reduced to were the air brakes taken from them?

ONE day's use of an air compressor for applying hose couplings paid the entire cost of the machine.

CORRESPONDENCE.

We invite correspondence upon matters of interest to the industries that may be improved by the introduction of compressed air. These cover a long list; among the most important ones may be mentioned mining, quarrying, rock excavation, submarine work. It may be used profitably in the following lines: Railroad and general machine shops, foundries and manufactories, bridge builders, distillers, chemical works, cold storage, ice manufacturers, steel foundries, soap factories, pipe manufacturers, lime manufacturers, cement manufacturers, rubber goods manufacturers, ship yards, boiler works, stone carvers and workers, water works, etc. The reason for adopting the compressed air system in connection with the industries is because of the simplicity in operation and its varied adaptability. It is free from danger and very reliable. Operations with it do not require the supervision of a specially qualified expert.

COMPRESSED AIR means to gather in the disintegrated information on this subject and present it to its readers in such form that each number will be a link in the chain of compressed air literature. The matter will be compiled so that all information regarding compressed air can be found under the covers of one publication. Every one interested should subscribe and extend the first journal devoted to this important science to every part of the world.

BY means of the compressed air refrigerating process we are enabled to keep fresh meat cool and transport it from Australia to England.

AT the Mexican International Exposition to be held in Mexico during the present year the rate charged per horse-power for steam and compressed air are the same. Electricity is 10 per cent. higher.

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GENESIS OF COMPRESSED AIR.

The application of the old time-honored saying, "There is nothing new under the sun," meets with no more striking illustration than in the harnessing of that mighty element—the air—to do man's bidding.

The seventeenth century demands and very justly merits our warmest admiration for one of its great inventions, the "air pump," and its creator, the famous burgomaster of Magdeburg, Otto von Guericke, was the wonder of his age; yet we are told that Galileo, not long before, made the discovery of the underlying principle of that and all such experiments, namely, that air is ponderable. However, could these and other great scientists have suspected that their knowledge was antedated more than a thousand years by a certain Heron of Alexandria, who lived, invented and died under the mummied Ptolemies, Philadelphus and Euergetes, they would doubtless have been not a little disconcerted. But they had no means of obtaining such information—happily for the peace of mind of their shades—for it has only been in recent years that any knowledge of the Egyptian inventor has come down to us, and this through such rare channels, that in a treatise by a noted French "savant," M. Duteus, on the "Origin of Discoveries Attributed to Modern Inventors" a work in which the author tries to make the best possible case for the Ancients, the name of Heron is not even mentioned.

Of late, however, the investigation of some of Heron's discovered writings, scanty as they are, and the finding of a few scattered notices bearing on his wonderful inventions, have developed a keen interest in their author and established his claim to be ranked with the leading lights of the world, among men of science and antiquaries in general.

Nothing is known of his life beyond the facts that he flourished between 284 and 221 B.C., and that he was the pupil of Ctesibus. Even his name is shrouded in mystery, so that while some speak of him as Heron, others feel justified in omitting the final "n." A certain popular celebrity has accrued to his name through the common pneumatic experiment called "Hero's Fountain," in which, as every student of Natural Philosophy will rememeber, a jet of water is sustained by compressed air.

Another claim to recognition is a steam engine of his invention—one spoken of at some length in his writings. This remarkable machine worked precisely on the principle of "Barker's Mill." A boiler with arms having lateral orifices is made to revolve around a vertical axis. The steam issues from the lateral orifices, and the uncompensated pressure upon the parts opposite the orifices turns the boiler in the direction opposite to that of the issue of the steam.

Still another engine described in Heron's Pneumatics has also a double forcing pump used for a fire engine, and various other applications of the elasticity of air and steam have all tended to secure him that position in the scientific world which has been attained by a few of the Ancients and is unanimously sustained by the cheerful readiness of us Moderns to recognize, appreciate and applaud the "divine spark" when discovered not only in our own times, but over the lapse of centuries.

F. L. W. MALOY.

Machine Shops.

The many uses to which compressed air can be applied have never been fully enumerated. Each day some genius adds another application. The builder, architect, contractor, engineer, master mechanic, superintendent and investor find that the employment of compressed air facilitates the work. The practices of machine shops in a long list of uses may be accelerated, simplified and improved by the introduction of air power.

VIEWS OF A NON-EXPERT.

These remarks are presented as the views of a non-expert, who has, nevertheless, been impressed for years with the possibilities of compressed air as a motive power in conjunction with an adequate mechanical medium.

The present advanced development of the power was foreshadowed from the beginning of the century: but the knowledge of the latent force of air in this condition far antedates even that period. As with nearly all the great powers of modern science and mechanics, progress has gone by slow and painful steps, through many failures, many apparently insurmountable difficulties, into the region of practical, universally acknowledged success.

The best known compressed air engine in the early years of the century was that invented by Dr. Sterling and his brother, James Sterling, C. E., of Edinburgh, Scotland, in the year 1816. The air was compressed for this machine to the pressure of from eight to ten atmospheres, but, as in the case of the early steam engines, the machine was not a commercial success. It had the effect, however, of stimulating interest and invention.

Captain Ericsson, who had not yet come to the United States to begin his work of revolutionizing modern war vessels, took up the idea and at length produced a working machine. It differed from Sterling's in being of much lower pressure. Its bulkiness, in proportion to power, and the intense heat evolved, were serious defects and rendered it only another link in the chain of experimentation.

In 1867 Sir George Cayley and Philander Shaw showed a machine at the Paris Exhibition of simple construction and greatly increased power. In this machine the compressed air was delivered into the furnaces, where, combined with the fuel, it formed the gases of combustion. The greater heat thereby produced was used to act upon the pistons and was then discharged. This machine avoided the defect of Ericsson's, in which the intense heat evolved acted as a destructive agent upon the machine itself. The heat "economizer" was also introduced. Through its medium the heat which is rejected by the fluid when it falls in temperature is saved and made to do work in conjunction with the direct power of the compressed air. A great difficulty has been the formation of ice in the pipes by the freezing of the water in the air; but this has been practically overcome.

In work in mines, tunnels and confined situations, compressed air has demonstrated its great superiority over steam or any other power. Thus in the boring of the great Mt. Cenis tunnel, air was compressed by water power and carried in pipes to the heart of the mountain to work the boring machines. In that situation steam would have been intolerable, owing to its discharge in the confined space. The compressed air also possessed another immense advantage, namely, the ventilation and cooling of the tunnel. As the compressed air was discharged it expanded to the status of the surrounding air, and as it expanded it fell in temperature, thus cooling the surrounding air and causing ventilation.

These earlier uses of compressed air were, however, only preparatory to the development of the power to-day.

Who can deny that this power has a great future before it? Its forces are drawn from the inexhaustible storehouse of the atmosphere; its economy is expressed, in part, by the old phrase, "as cheap as air."

Power and economy—the economy of power—is the great desideratum of industry and mechanics, the real philosopher's stone that will transmute all things to gold, and the chained energy of the air—chained to the perfected machine of this day of mechanical triumphs—is surely an ideal solution of the age-long problem.

JOHN J. ROONEY.

COMPRESSED AIR.

Compressed air is air under pressure. It is usual to define compressed air as air increased in density by pressure, but we may produce compressed air by heat alone, as illustrated by the discharge of a cork from an empty bottle when heated. Though one of the oldest of the sciences, compressed air is, in its development and use, one of the youngest. Hero, of Alexandria, a century before Christ experimented and wrote upon "Pneumatics," calling special attention to the influence of heat in expanding and contracting air. It is said that Hero put into practical use an invention by which the opening and closing of temple doors was effected by the alternate rarefaction and condensation of air which was brought in contact with heated and cooled surfaces of altar tops. Yet the science of pneumatics played no important part in industrial progress until scarcely more than a century ago it came into general use for diving-bells, and was later on applied by Brunel to caisson work.

In 1830 the French Academy of Sciences gave a medal to Thilorier for his method of compressing gases by stages. In 1849 the Baron von Rathen suggested the use of compressed air at 750 pounds pressure per square inch in locomotives. It is a singular fact that the Baron, in describing the method by which he proposed to attain this high pressure, advised compound compressors with inter-coolers. The special advantages of cooling the air between the different stages of compression were set forth. This stage compression and intercooling is one of the most important recent improvements made in air-compressing machinery.

Until recent years the use of compressed air in America has been confined almost exclusively to mining, tunneling, bridge-building, or to work in a confined space for which no other power was available. Electricity has recently become a competitor of compressed air in that it, too, may be used in confined spaces, and may be transmitted long distances and distributed. Until such competition arose the question of producing compressed air economically was but little agitated. The attention of engineers was mainly devoted to the development of an apparatus for using compressed air, it being taken for granted that air was an expensive power at best. The manufacturer sought to perfect his compressor on lines of low first cost, light weight, economy of space and general availability. Dry, pure air, delivered at a sufficient pressure by a machine which could be depended upon, has been the controlling consideration.

Compressed air and air-compressing machinery have been considered, and the science developed by two classes of men—the practical men and the engineers. The practical men confined their work to the machine. The confusing diagrams and figures of the engineers were not considered, because they were not understood. The engineers took occasional plunges into compressed air theories, producing figures controverting certain well-established and so-called practical facts, and almost invariably basing the conditions of compressed air economy upon questions of thermodynamics. The problems produced by the engineers were too mathematical for the practical compressed air men. These men knew too little of the theory of compressed air, hence progress in the science has been slow.

During recent years an impetus has been given to compressed air development by the strides made by electricity, and by the increased use of compressed air in the arts. Electricity, although apparently a competitor, has really played the part of a friend in pointing out the possibilities of transmission and use of air in directions before unknown; thus a market has been created.

The perfection of the air compressor on lines of economy naturally followed the

wide use of compressed air in competition with steam and electricity. The best steam engine practice has been applied to the compressor. Compound condensing Corliss engines are now used in connection with air cylinders of new design.

The whole subject of compressed air may be divided into three heads:

Production.

Transmission.

Use.

No better evidence is needed of the obscurity of the science, even among engineers, than the fact that it is the usual thing to look upon compressed air as an expensive power, because of the great loss which is suffered during transmission. The great losses and the serious difficulties encountered in reality do not belong to transmission. Compressed air power may be transmitted and distributed with no greater difficulty than the distribution and transmission of illuminating gas. It is a question of the size of pipe, volume and the pressure. There is not a properly designed compressed air installation in operation to-day that loses over five per cent. by the transmission alone. The question is altogether one of the size of pipe, and if the pipe is large enough the friction loss is a small item. It is undoubtedly true that there are places where a conduit has been laid for a certain volume of air, and where the supply has been increased without increasing the size of the conduit, the result of this being that more air is forced through the pipe than its sectional diameter will admit economically; hence the velocity of flow is increased, and as the friction is in direct proportion to the velocity the loss of power is also increased. The largest compressed air long-distance power plant in America is that at the Chapin Mines in Michigan, where the power is generated at Quinnesec Falls, and transmitted three miles. This is not an economical plant, but the loss of pressure, as shown by the gauge, is only two pounds, and this is the loss which may be laid strictly to transmission. During the construction of the Jeddo Tunnel, near Hazelton, Pa., compressed air at 60 pounds pressure was conveyed 10,860 feet from the central station. The writer was called upon to explain a mysterious condition which existed on both ends of the line. The pressure gauge recorded the same figures and the gauges were sent to the shops for repairs, because everybody was convinced that "something was wrong." The result was not changed when the gauges had been "repaired," it being evident that this apparently perfect economy of transmission was due to the fact that a large pipe (nearly six inches in diameter) was used at that time to convey so small a volume of air that the velocity in the pipe produced so small a friction loss that it could not be recorded on the gauge.

Having defined compressed air we must next define heat, for in dealing with compressed air we are brought face to face with the complex laws of Thermodynamics. When we produce compressed air we produce heat, and when we use compressed air as a power we produce cold. Based on the material theory of heat, it was said that when we take a certain volume of free air and compress it into a smaller space we get an increase of temperature, because we have the heat of the original volume occupying less space; but no one at this date accepts the material theory of heat. The science of Thermodynamics teaches that heat and mechanical energy are only different phases of the same thing, the one being the motion of molecules and the other that of masses. This is the accepted theory of heat. In other words, we do not believe that there is any such *thing* as heat, but that what we call heat is only the sensible effect of motion. In the cylinder of an air compressor the energy of the piston is converted in molecular motion in the air, and the result or the equivalent is heat. A higher temperature means an increased speed of vibration, and the lower temperature means that this speed of vibration is reduced. If we

hold an open cylinder in one hand and a piston in the other, and place the piston within the cylinder, we here have a confined volume of air at normal temperature and pressure. These particles of air are in motion and produce heat and pressure in proportion to that motion. Now, if we press the piston to a point in the center of the cylinder, that is, to one-half the stroke, we here decrease the distance between the cylinder head and the piston just one-half: hence each molecule of air strikes twice as many blows upon the piston and head in traveling the same distance, and the pressure is doubled. We have also produced heat (about 116 degrees), because we have expended a certain amount of work upon the air; the air has done no work in return, but we have increased the energy of molecular vibration in the air, and the result is heat.

But what of this heat? What harm does it do? If we instantly release the piston which we have forced to one-half stroke, it will return to its original position less only a fractional part, due to friction. We have, therefore, recovered all or nearly all the power spent in compressing the air. We have simply pressed and released a spring, and this illustration shows what a perfect spring compressed air is. We see also the possibility of expending one horse-power of energy upon air and getting almost one horse-power in return. Such would be the case in practical work if we could use the compressed air power *immediately and at the point where the compression took place.* This is scarcely possible, as the heat in the air is soon lost by radiation, and we have lost power.

Thirteen cubic feet of free air at normal temperature and barometric pressure weigh about 1 pound. In the illustration referred to about 116 degrees of heat are liberated at half stroke of a compressor. The gauge pressure at this point reaches 24 pounds. According to Mariotte's law, "the temperature remaining constant, the volume varies inversely as the pressure," we should have 15 pounds gauge pressure at half stroke. The difference, 9 pounds, represents the effect of the heat of compression in increasing the relative volume of the air.

The specific heat of air under constant pressure being 0.238, we have $0.238 \times 116 = 27.6$ heat units produced by compressing one pound, or 13 cubic feet, of free air into one-half its volume; 27.6×772 (Joule's equivalent) $= 21,307$ foot pounds. We know that 33,000 foot pounds is one horse-power, and we see how easily about two-thirds of a horse-power in heat units may be produced and lost in compressing one pound of air. Exactly this same loss is suffered when compressed air does work in an engine without reheating, and is expanded down to its original pressure. In other words, *the heat of compression and the cold of expansion are in degree equal.*

W. L. SAUNDERS.

[TO BE CONTINUED.]

Coal Mining.

As an exhibition of the economy and competency of compressed air over electricity in coal mining, an article printed in the *Journal of the Illinois Mining Institute* in August, 1892, brings out the following facts, which are valuable because they were contributed by a practical manager of a coal company, and are the result of experiments with both powers, and conditions being on an equal basis for both powers; the machinery employed, we presume, being of an equal grade. When put to work, the electrical apparatus proved incompetent, while the compressed air machine was entirely satisfactory. Another important statement made was that the cost of laying the pipe in this case did not exceed the cost of hanging the wire. The same article commended the use of compressed air from a sanitary standpoint and in points of safety and economy.

THE NEW TRAMWAY.

Horse cars are the ruin of street railways, therefore all cities are at present trying to substitute some means of mechanical traction, such as electricity or compressed air.

The electric traction known as "The Trolley," with its overhead system of wires and return by rail, has been somewhat developed in France through lack of anything better, but it carries with it many disadvantages. From a purely æsthetical point of view, it disfigures our cities with its many posts and the network of wires of which it is composed. Looked at from a point of safety, its many victims in Bordeaux, Lyons, Marseilles, Brussels, Gênes, etc., testify against it, to say nothing of the great havoc it has played with telegraph and telephone lines, water and gas pipes, etc. In the United States, from whence we received this system, New York, Washington and other large cities have prohibited its adoption.

In Paris, the "Compagnie des Omnibus," noting all these disadvantages, has used compressed air as one of its means of traction, though the methods employed up to date have been much more costly than had electricity been adopted. It has been necessary to use very high pressures in order to supply a sufficient amount of compressed air to last for the entire trip of the tramway. That necessitated having numerous engines, caused a considerable loss of time, and forced the building of heavy cars with large receivers, which materially added to the dead weight of the tramway. It became imperative to find a better and more economical method of utilizing compressed air, and that is what MM. Popp and Conti have done. They have presented to the members of the General Council of the Seine, to the Municipal Council of Paris, as well as to the chief engineers employed by the government, a tramway which seems to give absolute satisfaction. Though of light weight and graceful form, it is sufficiently strong to draw several other cars and also to accommodate forty passengers, who suffer no inconvenience from heat, unpleasant odors or disagreeable noises. It moves easily and rapidly, stopping quietly or suddenly at the will of the motorman, if by chance a horse or carriage crosses its path. It is even able to back on the track without disturbing either the passengers who are in the tramway or those who are on the two large platforms outside. At starting, the tramway is charged with a sufficient quantity of compressed air to enable it to run for four kilometres, after which distance it becomes self-charging, and by the following ingenious device.

Before each waiting station the rails are provided with a pipe which is set in the hollow over which the wheels pass. That causes a smaller pipe to spring from the ground and enter a hydraulic joint placed under the tramway, by which means the receivers installed there are connected with the underground conduit. The amount of compressed air received in a few seconds is sufficient to propel the tramway for a further distance of four kilometres. This done, the little pipe re-enters the ground and is automatically covered by an iron plate, over which men and horses alike may pass with perfect safety.

The Presidents of the General and Municipal Councils, as well as the members and the eminent engineers, MM. Huet, Boreux, Humblot, Petsch, Monmerquè, &c., who were present at the tests, warmly congratulated M. Victor Popp upon his success.

In conclusion, we trust Paris will follow in the footsteps of Saint-Quentin, Angouleme and Lyons, who have already adopted this system, and not wait for the Exposition of 1900 before giving the public a means of transportation which will be so greatly to its advantage.

CHARLES CHINCHOLLE.

Translated from *The Figaro*,
Paris, Dec. 28, 1895.

Railroad Shops.

IN the Union Pacific shops at Omaha, compressed air is used for sandpapering the sides of cars. A sandpapering disk is caused to rotate at about 2,500 revolutions per minute.

THE New York Central & Hudson River Railroad uses compressed air in their West Albany shops on all benches for cleaning injectors, checks, cocks, and all classes of work that require cleaning.

THE Southern Railroad Company use compressed air for such work as sand blasting, loading and unloading heavy supplies, such as car wheels, etc., raising and lowering cabs and many other purposes.

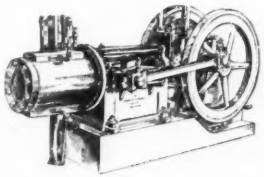
MR. J. H. MCCONNELL, of the Union Pacific System, says: "We are constantly finding more uses for compressed air, and at the present time we find that it would be an impossibility to get along with our work without its use."

A Popular Belt Compressor.

THE NEW LOOKING BACKWARD.

GREATER NEW YORK,
March 10th, A.D. 2000.

Editor Compressed Air:



THE anticipation of the year of millenium under the dispensation of the latter-day prophets had filled us with such feelings of glee, that when it arrived we were quite unprepared for it. However, we are making the best of the situation, and when we had to tone down our progress to a sensible pace we found the result of thus attuning ourselves a decided advantage in every way.

We have hardly overcome the custom of dating our correspondence 1999, although it is now 2000. The writers and philosophers of your day persisted in designating electricity which appeared to them to be the acme of power and the great means of all that related to comfort and convenience. Myself and Old Bill Baker, who is here with me, have many a hearty laugh over the heavy and stolid mass of literature that the boys used to grind out concerning the delights of this day when human effort should be reduced to the minimum shade of exertion. We used to look forward to these times with wonderment and vagueness because of the uncertain aspect that things assumed, filtered through another fellow's brain. But it is all as natural as breathing. The great improvement in every method is as confusing as it is advantageous. An enumeration of them would be a stupendous work. I will describe them briefly as they occur to me.

One of the great advances is thatof transportation. The cable car of 1896 was considered a model of transit accommodation. I look out of our office window and see the

result of the transformation, and it is astonishing. People are sitting on a semi-invisible seat and moving up and down town with great rapidity. It seems that the new motive power has evolved into this arrangement: The conduit of the cable road is filled with air and the slot allows it to escape, and this forms an air cushion upon which the seat seems to rest.

You remember how the Brooklyn Base Ball Club used to get its winter practice in base running. The players used to try to cross the street in front of the trolley cars. The opposite corner was called the base. The player after making a fierce run and sliding on his stomach to touch the base or corner, would feel proud to think that the car "never touched him." It took a person of much agility to escape. Old Bill can never let such memories pass out of his mind. He tells stories of these appliances to the great amusement of his hearers.

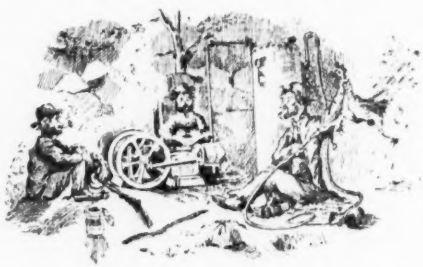
Instead of irrigating the soil we now irrigate the atmosphere. There are no pulmonary diseases, no asthma, no catarrh, no rheumatism, and in fact nearly all diseases have vanished. The temperature is kept even and rarefied in all places. The building which we occupy is a ten-story one, and Bill is now cutting up a couple of newspapers to make an æroplane to go over to Brooklyn with. After he makes it he steps to the window and the flight takes but a few minutes. He has to take the compressed air line back, because without the regular apparatus you cannot get the ascension. We used to think that the path to perfect government was to solve the economic question, but that was a great mistake. The ills that human flesh is heir to was the cause of most of the trouble between the poor and the rich, but a half century of existence under the influences of improved conditions, resulting from the knowledge of the atmosphere and its proper use, has abolished this. People are of a higher grade in physical culture. The old maxim that all men are created equal is now accomplished in reality. The people don't overdo the matter. There were men in your time that understood the value of air power. Its proper and economical compression was the study of their lives; they endeavored to show people that compressed air and pneumatics were practical means of labor-saving. But a greater portion did not take any interest in it; they ran mad after electricity.

Pneumatic Tools.

Compressed air appliances are slowly but surely finding their way into all the leading manufactories of this country. Wherever pneumatic tools are used—and they are used in many shipyards, boiler building works, marble yards, etc.—there also are compressed air plants to be found. The Pennsylvania Railroad have air hoists in their West Philadelphia blacksmith shops, which they are operating to their entire satisfaction, and the United States Government is testing a compressed air fog horn, which will undoubtedly supercede the steam fog horns hitherto used.

Pumping water from subterranean sources can best be accomplished by compressed air. We propose to deal more fully with this subject in subsequent numbers of this little magazine.

Camped in a Convenient Place.



One of the Many Useful Applications of Compressed Air.

COMPRESSED AIR LOCOMOTIVES.

(*From the Coal Trade Journal.*)

Under certain conditions in mines or in warehouses where smoke or fire is undesirable, locomotives propelled by compressed air have performed useful service. At Vivian, W. Va., certain of them have been put at work. The new locomotives are approximately 10 feet 5½ inches long, 5 feet 8 inches wide and 4 feet 5 inches high, and weigh 10,000 pounds. It will readily be seen from these figures that they are adapted for running in very small openings. The cylinders are 5 feet 10 inches, and the driving wheels, of which there are four, are 23 inches in diameter. The storage tank has a capacity of 47 cubic feet of air and a working pressure of 535 pounds per square inch, and there is also an auxiliary reservoir. The locomotive main tank is designed for 600 pounds, but the working pressure for the service intended is about 535 pounds. A three stage compressor is used, pumping into a 3-inch pipe line, which serves to connect the compressor to the most convenient point of charging the motors, and also acts as an air reservoir, the compressor and pipe line being competent to withstand a pressure of 850 pounds.

These locomotives, which take the place of mules, are to be used in side entries and in making up trains in the rooms of the mine and delivering the trains to the main entry, where they are handled by steam locomotives. The average length of each side entry is 4,500 feet, with grades of 1¾ per cent. in favor of the loaded cars. The gauge of the track is 3 feet 8 inches, the weight of the rails 16 pounds per yard and the radius of the sharpest curve 24 feet. The locomotives are designed to make the round trip of 9,000 feet, with six cars, with one charge of air and to work on curves of 15 feet radius. The weight of the loaded cars is about 8,500 pounds.

This is said to be the first introduction of any kind of mechanical haulage anywhere for sole use in butt entries and rooms. The low cost of installation and operation and the greater adaptation to the conditions of the service and requirements caused the pneumatic system of haulage to be adopted in preference to electric haulage, although an electric plant had already been determined upon for working the mining machines.

In General Mines.

Compressed air has been used in mines for drilling and ventilating and for other purposes for many years. No mine can hope to compete in production unless it has in its equipment an air compressing plant.

Mining has been one of the greatest means of giving prominence to compressed air. It has been used in underground operations to the great comfort of mankind.

Where free atmosphere could not find access compressed air has been conducted, making it pleasant and habitable for those whose duties compel them to be in confined places.

The air compressor is an engine of strength and great utility. Its uses in connection with pneumatic tools brings the building of machinery up to a high standard of excellence and at a reduced cost. Compressed air lightens the burden of the laborer by lifting heavy weights.

The progress of compressed air has been slow because only a few came in contact with it, and its value was hidden. Electricity, on the other hand, has had an advantage. The plants that distribute light to cities and towns and families attracted the attention of every one from the fact of its own evidence. A huge air compressing plant may be doing an important work unseen.

THE different processes of shearing can be readily accomplished by means of Compressed air.

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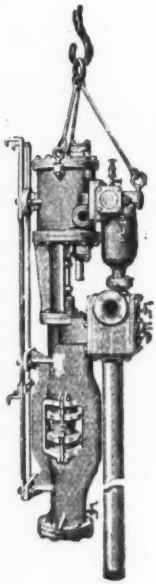

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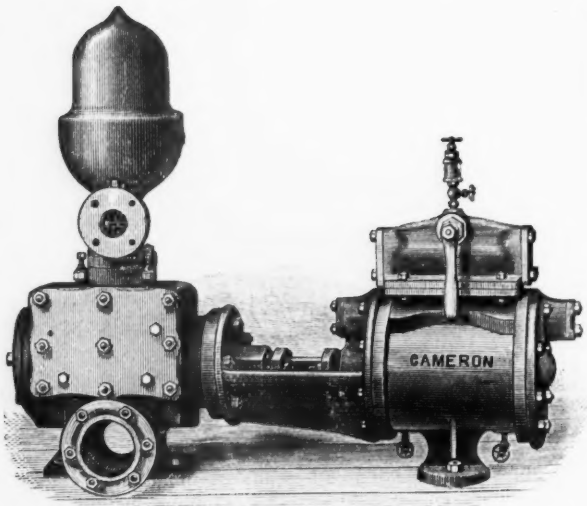

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Foot East 23d Street, New York.

Compressed Air

A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

W. L. SAUNDERS, - - Editor and Publisher
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J. E. QUINTERO,) - - - - - Associates

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Those who fail to receive papers promptly will please notify us at once.

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THOSE who object to the proposed Underground Road in New York, on the basis that all underground roads and tunnels are disagreeable places, do not make allowance for recent improvements in construction, ventilation, lighting and traction.

In building a tunnel through Broadway, every machine can and should be operated by compressed air. Power might readily be generated in the basement of a building along the line of the street and transmitted through pipes to the hoists, pumps, drills and excavators. There need be no disagreeable puffing of steam, smoke, or moving about of heavy boilers with their attendant loads of coal, water and ashes. There will be nothing experimental about this, because it has been done on the Chicago Drainage Canal, on the new Croton Aqueduct, and on hundreds of other places of less importance.

Why talk about difficulty in ventilating a road under Broadway, when each train can be pulled by a compressed air locomotive which will puff dry, cool and fresh air into the tunnel at each stroke? The H. K. Porter Co., of Pittsburg, has built and put into successful operation engines for such duty as this. Imagine the trains as close together as those on the elevated roads, and it is not difficult to see the wholesome effect of the locomotives puffing pure air into the tunnel. Compressed air for this purpose should be produced by compound or stage compressors. This is not only an economical condition, but it prevents the oily or burnt odor sometimes noticed in mines which receive compressed air from the common type of non-compound compressor. Mr. E. J. Farrell, the experienced contractor who built the Baltimore tunnel, claims that the wholesome effect of compressed air exhausted into a tunnel is greater than that produced by any other means of ventilation. He has found that the exhaust from six rock drills is better than the effect produced by a No. 6 Baker blower. The six drills deliver about five hundred cubic feet of free air per minute, while the capacity of the blower is four thousand five hundred cubic feet. In the case of the drill, the air does work before it is exhausted into the tunnel; hence its heat is converted into mechanical energy. The blower simply supplies fresh air from the outside and at normal conditions of temperature and prsssure.

Chief Engineer Parsons has planned wisely in keeping the tunnel as near the street as possible. It will be more accessible, dryer and more easily lighted. A waterproof lining will keep out the moisture. Compressed air, which should be on tap all along the line, might be used to light the tunnel on the Wells' light principle. This light is now a familiar one in public works, its great luminosity being very marked. The light is more diffused than the electric or any other light. As the combustion is fairly complete, there is not likely to be any injury to the ventilation, though the light might serve the

double purpose of lighting and ventilation by being placed directly under vents or chimneys, and thus ejecting large volumes of air from the tunnel.

In the light of recent improvements, there is nothing mysterious or difficult about the construction and operation of underground roads.

WORDS OF ENCOURAGEMENT.

I am very glad to get the little magazine, and am sure that it will prove a valuable addition to my library.

R. H. THURSTON.
Sibley College, Cornell University,
Ithaca, N. Y.

I must congratulate you on your foresight in pre-empting the field by COMPRESSED AIR. I have great faith in its future, and believe it will be the coming power, especially for local plants when it can be generated by large water-powers and be carried long distances under high pressures, as at Niagara, Spokane, Duluth, etc. L. M. HAUPT.
Con. Engineer,
Philadelphia, Pa.

I have looked over the first copy of COMPRESSED AIR, and think your object in its publication is a very good one.

ELMER H. LAWALL.
Lehigh & Wilkesbarre Coal Co.,
Wilkesbarre, Pa.

We are much pleased with the sample copy of COMPRESSED AIR just received. We think it should serve as a good medium for further advancing the sales of compressed air apparatus and bring the merits of the same more clearly before the public. E. P. LORD,
H. K. Porter & Co., Supt.
Pittsburg, Pa.

It is a step in the right direction, educating the masses in the power they breathe.

WM. A PARKER.
Kansas City, Mo., March 15.

I have read with much interest the first copy of COMPRESSED AIR. It is a cleverly executed idea in the right direction, and I predict success for your journal.

HENRY D. COOKE.
American Air Power Co.,
160 Broadway, N. Y.

This little magazine should have the hearty support of every live person, because none of us could exist very long without that essential medium which it so ably treats of—Air.

There is no subject that has such a boundless area open for scientific researches as the power which is constantly forcing itself upon us for recognition at the rate of 15 pounds per square inch.

C. FRANK SCHWEP.
Easton, Pa.

I enclose herewith one dollar as subscription to COMPRESSED AIR. I do this because I want to encourage your effort in not having the public understand what compressed air is going to do for street motors alone, but for the thousand and one other things.

The fact is, it is used to much greater extent than the public have any idea of, and it is going to continue to increase, and I hope you will keep right up with the procession. FRED. C. WEIR.
Cincinnati, O.

DON'T imagine because COMPRESSED AIR began as a little magazine, that you are not going to get your money's worth. The practice has been toward the voluminous in journals, but the tendency now is to reduce the size of them. Paper is one of the cheapest commodities there is. The size was adopted because we wish to carry out the idea expressed in our heading, *Compressed* air.

EARLY PNEUMATICS.

At a time when a work on "the Seven Wonders of the World," was more or less a record of contemporaneous history but with just enough flavor of antiquity to make the era of 250 B. C. seem comparatively young and progressive—in that complacent, tolerant way, with which human nature is wont to view past achievement in the light of present possibility—Philon of Byzantium wrote his "Ancient History," recorded the work of his beloved Master Ctesibius, chronicled some truly marvelous discoveries and inventions of his own and completed the mission of his destiny on the field of battle, 212 B. C.

His descriptions of "the Hanging Gardens of Assyria," "the Pyramids of Egypt," "the Statue of Jupiter Olympus," the Colossus of Rhodes" and all the other wonderful creations of the early genius of man, which constitute the world-famous "Seven Wonders," are set forth with a grace and elegance worthy of present imitation, but, in many places, with a too-studied regard to rhetorical effect which robs the writings of that directness of simplicity without which no work can hope to live, in its first freshness forever. Therefore it is that musty book-shelves and worm eaten tomes must be consulted to learn of Philon the "literateur"—but Philon the mechanician and ancient authority on the besieging and defending of cities, seems quite another personage.

Two of his books on military engineering, are on the general subject of the manufacture of missiles, while a third covers a wide range, including the arming of harbors, the use of levers and such mechanical powers, as also other contrivances connected with the storming and resisting of towns. In the latter, he advocates a strange and barbarous system of warfare, advising that on the approach of the enemy through an open country, all springs and grain be poisoned. For this policy, even in ancient times, he was severely censured.

But modern attention has been directed to him chiefly through his notice of an invention of Ctesibius—that master mind, for the sake of whose teachings Philon left his home and removed to Alexandria to become, like Heron, his instructor's devoted desciple.

This invention was an instrument of war, and consisted of a tube out of which an arrow was shot by means of compressed air. This is one of the oldest applications of that mysterious force, the modern air-gun being an evolution of Ctesibius' ingenious machine.

Over sixteen centuries elapsed between the first invention and the next model, and in 1560 we find that the new gun had a butt end of hollowed metal containing a reservoir in which air was compressed by means of a force pump. The balls were placed in the little receptacle, which was furnished by a stop-cock, and as one shot was sent off, the stop-cock was opened and a fresh projectile inserted. Naturally, the force of projection diminished as the reservoir of compressed air emptied, so that after every few discharges, it became necessary to re-compress the air.

Some years later this model was improved upon, but even in its best form, it has left much to be desired in point of time saving, and furnishes a golden opportunity to some nineteenth century genius to make the air-gun a more deadly weapon than its rival in fire-arms—or better still, to devise a machine of such dimensions that so vast a quantity of air could be compressed within it, that its liberation would annihilate the largest army ever massed together among the nations.

Thus might the possibility of war be averted by the appalling consequences of facing an unchained element made obedient to the operation of a single individual.

FRANCES MALOY.

TO RUN BY AIR.

ENTIRE PULLMAN PLANT WILL BE OPERATED BY THE POWER.

(Chicago Times-Herald.)

Compressed air as a power has displaced steam in three departments of the Pullman Palace Car Company's works, and the results have so far satisfied the officials that in all probability the new force will be in use shortly in all the great shops of the corporation. The change is radical and marks a revolution in the manufacturing system of the great Pullman plant.

The argument advanced at Pullman yesterday in favor of a change from steam to compressed air was, in short, great saving in manual labor, economy, ability to transmit power long distances without loss of force, simplicity, safety and convenience. An official of the Pullman company was sent to Omaha and Topeka to go through the shops of the Union Pacific and Santa Fe railroads and to make a report on the general efficiency and economy of compressed air as applied there in the department of carmaking. He has just returned and his report strongly favors the adoption of the system throughout all the car shops at Pullman.

DANGEROUS BELTS DONE AWAY WITH.

The introduction of compressed air means the doing away with the great iron wheels which revolve near the ceiling in all the shops. The belts which run from these wheels to the work benches and which not infrequently pick up a workman and whirl his life out, will soon be things of the past. To take their place a pipe will run along each wall just back of the benches. In front of each workman a small tube will connect with the main pipe and with whatever bit of machinery he has to do. When the workman wishes to shut off his machine he simply has to close a stopcock. To start the machine he reverses the operation. Under the steam system the belt has to be slipped to one side, but it goes on running ceaselessly and noisily. With the air system it is claimed that the speed of the machine in use may be graded, something that is impossible when a belt is used.

Compressed air is already in use at Pullman for lifting purposes, for the testing of air brakes and for the cleaning of carpets and upholstery.

There are ten engines to supply steam for the running of the machinery in the different departments at Pullman. The engines are so placed that the work which each has to do is in its immediate neighborhood. An officer of the company says that with compressed air as a motive power probably not more than one centrally located large engine would be necessary, because the air lost so little of its force when being transmitted to a distance. It was said that at Topeka, at a distance of half a mile from the source of supply, compressed air lost less than 20 per cent. of its power. Steam at the same distance loses more than 50 per cent. of its force. "Fully 30 per cent. of our steam power here at Pullman," continued the official, "is taken up by the belting. This loss is saved by the compressed air system. Add to the 30 per cent. lost to the belts the amount lost in transmission, and you will see the immense advantage in economy of force that compressed air has over steam. I am not well posted on the fuel economy question, but those who have made a longer study of the air power than I, say that there is a great saving at the compressing end."

ADVANTAGE OVER ELECTRICITY.

"Here we compress our air and store it in tanks. That is the general custom, for you then always have a supply in case anything happens to the compressor. Compressed air has an advantage over electricity in that it is not dangerous, and because it cannot start fires. In riveting, in break-

ing stay bolts and in general boiler work the use of compressed air saves one-half the manual labor necessary under other systems."

When they started cleaning carpets by air the other day at Pullman, those who had been accustomed to the switch pounding, arm-tiring method, looked on with something more than wonder. The air came out with a "swish," struck a spot in the carpet, and the dirt vanished. For brake testing the compressed air method is pronounced superior to every other.

Sheep Shearing in Australia.

Many attempts to perfect a mechanical device which would lighten the work for the shearer, prevent the wool from being injured by second cuts and guarantee the neat fleece to be even in length, or "wool topped" have in the past twenty years been made.

A machine such as we illustrate on the cover was invented, and is simple and easy to handle. The simplicity of the construction dispenses with the necessity of skilled labor in setting up, adjusting or running the machine.

The use of this machine reduces the time of shearing from an average of 70 sheep by hand to about 100 per day of ten hours, or in other words one machine can accomplish in one day as much work as it formerly required three men to turn out.

Another point in favor of this invention is that by its use the animals are never mutilated, and the wool brings a better price in the market, on account of the length of its fibres.

In Australia, the foremost country for sheep raising in the World, this machine has been introduced and is being used on a large scale with most satisfactory results.

WE have just received a copy of Edward Wegmann's book, entitled "The Water Supply of the City of New York," published by John Wiley & Son, N. Y. It is a thorough and comprehensive history of the excavation of the great aqueduct tunnel, the longest tunnel in the world. Plans, specifications and contract prices are given for almost every detail of waterworks construction. In describing, the author writes from his own observation and experience. The new Croton Aqueduct has a maximum capacity of 302,000,000 gallons of water in 24 hours. The two other conduits have a maximum capacity of 123,000,000 gallons in 24 hours. Compressed air appliances were used in the excavation of the tunnel to a very extensive degree. A number of air compressors of high efficiency were used to distribute power to the rock drills.

From the compressor the air, raised to a pressure of 80 to 100 pounds per square inch, was conducted first to a cylindrical wrought-iron receiver and having a diameter of 3 to 5 feet and a length 8 to 14 feet. The object of the receiver, which was placed generally out of doors, was to equalize variations in the pressures and delivery of the air.

A portion of the reading matter is devoted to the new Jerome Park Reservoir. The work on this reservoir involves the excavation of about 7,000,000 cubic yards of rock and earth, and the contract was awarded to John B. McDonald in August last. Compressed air will be used in this work. It will be transmitted to drills, engines, pumps, hoisting machinery, etc. The contractor is goin to adopt a compressed air central plant system as the most efficient and economical.

Several air compressors will be placed side by side, and the result is looked for as an important example, and will demonstrate the availability of compressed air and its direct application to specific uses.

The reservoir will have a water surface of about 228 acres and will store abont 1,900,000,000 gallons of water.

COMPRESSED AIR.

CONTINUED FROM LAST NUMBER.

Figure 1 is a sketch designed to indicate graphically the effect of heat and cold in compression and expansion of air.

The sketch illustrates an open cylinder, which may serve both as an air compressor and an air engine. The piston at the point shown is supposed to confine a volume of free air in the cylinder and at a temperature of 60 degrees; let it be pressed down until it reaches the point indicated by 45 pounds, and the pressure will follow the dotted lines marked "Adiabatic." This is, of course, assuming that the heat, which is invariably produced by compression, is suffered to remain in the air and to influence the pressure. We here have a confined volume of compressed air at a pressure of 45 pounds and a temperature of 320 degrees. Let there be no absorption of heat and the piston if released will return to the starting point, the pressure following exactly the line indicated during compression and the temperature returning to 60 degrees. In such a case we assume, of course, that the piston is frictionless. This points to the fact that compressed air is a perfect spring, and that the heat of compression when utilized can be made to return its full value of energy.

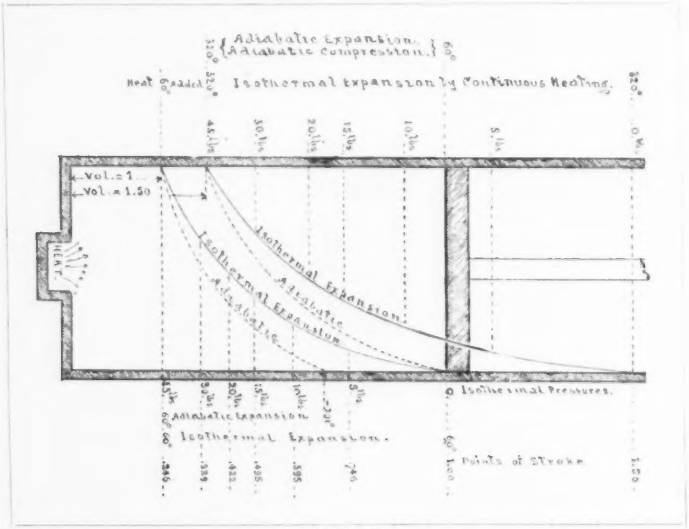


FIG. 1.

An Air Compressor provided with no cooling device would show a pressure line following closely that marked "Adiabatic" on Fig. 1. The hot compressed air confined in the cylinder at the 45-pound point, if transferred through pipes to an air engine and maintained hot until used, would be available for work in the same proportion (less a little friction) as we have shown in the theoretical case where the piston, used as a compressor, is driven back to the starting point. Practically, it is impossible to convey hot compressed air any distance from the compressor, for air, though very slow in taking up heat, has so low a specific heat that it parts with its temperature rapidly. Steam having a higher specific heat may be conveyed as a power even through naked pipes, and this fact has led to mistakes in regard to the possibilities with compressed air.

Returning to Fig. 1, let us imagine that the piston has been stopped at the 45-pound

point, and that the compressed air, which, as we have seen, has a temperature of 320 degrees, is transferred into a receiver and used at a point say half a mile distant. The temperature will now be reduced to that of the surrounding medium, or to the initial temperature, which the sketch shows to be 60 degrees; and if the system is well designed, that is, if the pipes are large enough and there are no leaks or other irregularities, we will have nearly 45 pounds pressure on the other end of the line, as there is a temperature of the air when exhausted at atmospheric pressure. We now see that the piston, instead of returning to the starting point, has only had power enough behind it to return it to a point about half way.

The illustration points to the importance in compressed air economy of reducing to the lowest point practicable the temperature of the air before and during compression and conversely increasing to the highest point the temperature before and during use or expansion.

TABLE I.—OF THE VOLUME AND WEIGHT OF DRY AIR AT DIFFERENT TEMPERATURES UNDER A CONSTANT ATMOSPHERIC PRESSURE OF 29.92 INCHES OF MERCURY IN THE BAROMETER (ONE ATMOSPHERE), THE VOLUME AT 32° FAHRENHEIT BEING 1.

Temperature in degrees.	Volume in cubic feet.	Weight of a cubic foot in lb.	Temperature in degrees.	Volume in cubic feet.	Weight of a cubic foot in lb.	Temperature in degrees.	Volume in cubic feet.	Weight of a cubic foot in lb.
32	1·000	0·0807	275	1·495	0·0540	1,300	3·585	0·0225
42	1·020	0·0791	300	1·546	0·0522	1,400	3·789	0·0213
52	1·041	0·0776	325	1·597	0·0506	1,500	3·993	0·0202
62	1·061	0·0761	350	1·648	0·0490	1,600	4·197	0·0192
72	1·082	0·0747	375	1·689	0·0477	1,700	4·401	0·0183
82	1·102	0·0733	400	1·750	0·0461	1,800	4·605	0·0175
92	1·122	0·0720	450	1·852	0·0436	1,900	4·809	0·0168
102	1·143	0·0707	500	1·954	0·0413	2,000	5·012	0·0161
112	1·163	0·0694	550	2·056	0·0384	2,100	5·216	0·0155
122	1·184	0·0682	600	2·158	0·0376	2,200	5·420	0·0149
132	1·204	0·0671	650	2·260	0·0357	2,300	5·624	0·0142
142	1·224	0·0660	700	2·362	0·0338	2,400	5·828	0·0138
152	1·245	0·0649	750	2·464	0·0328	2,500	6·032	0·0133
162	1·265	0·0638	800	2·566	0·0315	2,600	6·236	0·0130
172	1·285	0·0628	850	2·668	0·0303	2,700	6·440	0·0125
182	1·306	0·0618	900	2·770	0·0292	2·800	6·644	0·0121
192	1·325	0·0609	950	2·872	0·0281	2,900	6·847	0·0118
202	1·347	0·0600	1,000	2·974	0·0268	3,000	7·051	0.0114
212	1·367	0·0591	1,100	3·177	0·0254	3,100	7·255	0·0111
230	1·404	0·0575	1,200	3·381	0·0239	3,200	7·459	0·0108
250	1·444	0·0559						

direct elastic medium between the two points. But the volume will be reduced in size, because of the reduced temperature, and will correspond with the space underneath the lowest dotted line in the figure marked "Volume 1." If it is now used without reheating to do work in an engine, the line of reduction in pressure will follow the lower dotted line marked "Adiabatic" until it reaches the point marked 201 degrees, which represents the theoretical

If, in the case referred to, heat had been applied during expansion, the pressure would follow the line marked "Isothermal Expansion," and the piston might be returned to the starting point.

Another case is shown by the sketch in which the air is compressed adiabatically to 45 pounds pressure and heat enough is applied during expansion to maintain the temperature at 320 degrees until the air is exhausted at atmospheric pressure. This

case is purely theoretical and illustrates the possibility of obtaining more power out of a given volume of air after compression than was expended at the compressor.

Experiments made by M. Regnault and others on the influence of heat on pressures and volumes of gases have enabled us to fix the absolute zero of temperature as about –461 degrees Fahrenheit. This point, —461 degrees below zero, has been taken to be the theoretical point at which a volume of air is reduced to nothing. The exact figures representing absolute zero vary with different authors, but for all practical purposes –461 degrees F. is near enough. The volume of air at different temperatures is in proportion to the absolute temperature, and on this basis Box has produced table 1.

The effect of the heat of compression in increasing the volume, and the heat produced at different stages of compression, are shown by table 2 (Box):

A cubic foot of free air at a pressure of one atmosphere (equal to 14.7 pounds above a vacuum) at a temperature of 60 degrees when compressed to twenty-five atmospheres, will register 367.5 pounds above a vacuum (352.8 pounds gauge pressure) will occupy a volume of 0.1020 cubic foot, will have a temperature of 864 degrees, and the total increase of temperature is 804 degrees.

These tables apply to dry air only. The effect of moisture will vary the figures of temperature and to some extent will affect the pressures, but many useful deductions may be drawn from the tables. It is seen for instance by studying table 1 that a volume of dry air will be doubled if its temperature is increased about 500 degrees, and conversely, of course, if the volume remains constant an increase of about 500 degrees in temperature will double the pressure. The addition of moisture serves to increase these figures, because moisture increases both the specific heat and the heat conducting capacity of the air.

W. L. SAUNDERS.

[TO BE CONTINUED.]

TABLE 2.—HEAT PRODUCED BY COMPRESSION OF AIR.

Atmospheres.	Pressure.		Volume in Cubic Feet.	Temperature of the Air throughout the Process. Degrees.	Total Increase of Temperature. Degrees.
	Pounds per Sq. Inch above a Vacuum.	Pounds per Sq. Inch above the Atm'sph're (Gauge Pressure).			
1·00	14·70	0·00	1·0000	60·0	00·0
1·10	16·17	1.47	0·9346	74·6	14·6
1·25	18·37	3·67	0·8536	94·8	34·8
1·50	22·05	7·35	0·7501	124·9	64·9
1·75	25·81	11·11	0·6724	151·6	91·6
2·00	29·40	14·70	0·6117	175·8	115·8
2·50	36·70	22·00	0·5221	218·3	158·3
3·00	44·10	29·40	0·4588	255·1	195·1
3·50	51·40	36·70	0·4113	287·8	227·8
4·00	58·80	44·10	0·3741	317·4	257·4
5·00	73·50	58·80	0·3194	369·4	309·4
6·00	88·20	73·50	0·2806	414·5	354·5
7·00	102·90	88·20	0·2516	454·5	394·5
8·00	117·60	102·90	0·2288	490·6	430·6
9·00	132·30	117·60	0·2105	523·7	463·4
10·00	147·00	132·30	0·1953	554·0	494·0
15·00	220·50	205·80	0·1465	681·0	621·0
20·00	294·00	279·30	0·1195	781·0	721·0
25·00	367·50	352·80	0·1020	864·0	804·0

Compressed Air in Machine Shops and Foundries.

IN *Cassier's Magazine* for August, 1895, Mr. C. O. Heggem writes instructively on the utility of compressed air for the transmission of power to out-of-the-way places and for use in lifts and hoists in machine shops, and also describes the various machines that are operated by air power.

In machine shops compressed air serves as a helper for the machine hand in a far more efficient and economical manner than that rendered by the manual help, which in some shops require an order from the foreman and a great deal of time lost.

All the attendant annoyances may be overcome by putting in air lifts over all lathes above 20 inches swing and over all planers, shapers, drilling machines, and drill presses working on pieces too heavy for one man to lift, and so quick and satisfactory are they in their action as to leave out of comparison all chain blocks or chain rigs of any kind. A very cheap form of air lift is a plain cylinder, suspended from a trolley traveling on a swinging arm, the cylinder being about four feet long, and for all lathes below 36 inch swing, or planers 30x30 inches, it need not be more than 6 inches in diameter, and yet will lift about 2,000 pounds with an air pressure of 80 pounds per square inch.

Chucks, face plates and steady rests can be lifted from the floor and placed in position by the aid of the compressed air hoist in less time than by hand, and work can be lifted and placed against the face plate or in the chuck with more satisfaction and in less time than by any manner of "blocking up" in vogue with the old helper system.

Very convenient little presses can be fixed up for driving mandrels, pressing in seats for valves, linings in piston rod glands, etc. The presses are made with a cylinder 16 inches in diameter, which at 80 pounds pressure is equal to about 16,000 pounds pressure on the ram. This compressed air press will at once commend itself for accuracy and avoidance of many accidents.

In turning soft steel shafting it is customary to use water to which a certain percentage of sal soda has been added in order that the water may not rust the finished work.

As the tool is being crowded away it crowds more over the harder portion of the steel than softer ones, and the result is, in addition to a tapering shaft one is also produced that is not round.

By using a small air jet—that is, air issuing from an orifice of about 1-16 inch in diameter, the work can be finished very much the same as if water is used. A smooth surface will be produced with this important difference, that the tool will not crowd, and, consequently, the shaft will be nearer true and straight when using compressed air than when using water.

The same size of air jet may be used to advantage at different places around the shop. It is excellent for cleaning off benches and machines, and is much to be preferred to the common dust brush for this purpose.

Punching may be done by having a small cylinder at the back end or arm, suitably pivoted, at the other end of which the attachment is made to the head carrying the punch. Such an arrangement is especially well adapted for quick work in the construction of smokestacks, breechings, tanks, and all work not requiring heavier than ⅛ inch, or, say, No. 8 gauge of iron or steel. With these presses arranged so as to be operated by a foot tripping device and equipped with jigs, it is surprising how much more can be done than by any other system of laying out.

A number of special tools have been on the market for some time, made for compressed air caulking. Some of these tools do the work very effectively, and with a minimum amount of discomfort to the man

running it, in the shape of reduced jar.

It is an incontrovertible fact that caulking is done better and can be done very much cheaper by air pressure than by hand.

From the machine shop and boiler shop Mr. Heggem goes to the foundry, and there on every side he hears the blasts of escaping air. Here are direct lifts or suspended cylinders of five tons capacity. Copes are lifted off without any jar. Patterns are lifted out just as slowly as you please until they are clear of the mould. Large green cores are placed in position to dry, without jar or shock of any kind.

Compressed air for lifting and other purposes in the foundry will commend itself to any practical foundryman without using any argument whatever in its favor.

In the same article the writer gives practical advice to those contemplating compressed air. He says: "Put in a compressor two or three times as large as you think you will actually need, and a belted compressor is to be preferred to a steam-driven one where the main engine running the shop machinery is sufficiently large to carry this addition. It is preferable because it is more economically run, no matter from what standpoint the economy is viewed."

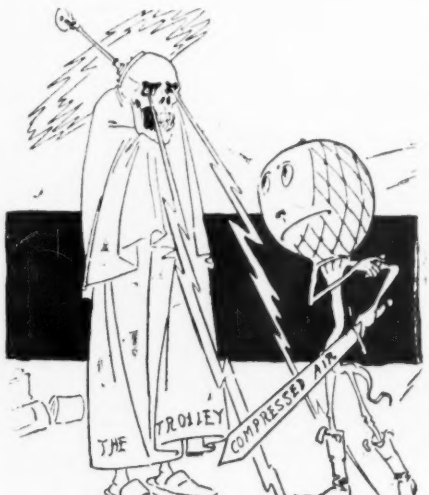
A Pneumatic Belt Shifter.

One of the latest useful applications of compressed air in machine shops is reported in the April *Locomotive Engineering*.

The device is applied to countershafting, for the purpose of shifting a belt from the loose to the tight pulleys, and the reverse. It consists of a small air cylinder with a piston travel, such as will give a belt the proper throw; the cylinder is piped from each end to a two way cock, the plug of which has a bar with a looped cord within reach of the operator. Attached to the piston is an arm which extends down to the bar carrying the shifting forks—air does the rest.

We want subscribers for "COMPRESSED AIR." We want people to buy the little Magazine because of its worth, which will from month to month become apparent. The cause which it is devoted to is another step in the direction of scientific advancement. Its mission is not one that is merely an appeal to sentiment, or the development of a theory that must sooner or later die out. "COMPRESSED AIR" has a sound reason for its existence. Not the enthusiasm of a moment but the result of years of mature experience in practical fields. "COMPRESSED AIR" will live because it is patronized, and you should patronize it.

THE use of compressed air for aerating molten iron has caused such a revolutionary effect upon the world's industries as to be alone worthy of comparison with the invention of the dynamo.



THE TROLLEY HAS A RIVAL.
From Chicago-Times Herald.

THE AIR BRAKE.

As early as 1852 a patent was granted in this country for an alleged invention of a railway brake operated by steam, and a few years later patents were issued in England for alleged air-brakes, but the first practical air-brake was not produced until about 1869, when George Westinghouse, Jr., of this country, invented what was then known as the "plain-brake." This consisted of a pump operated by steam from the locomotive boiler, which compressed air into a reservoir located under the locomotive cab. This was under the control of the engineer by a valve in a pipe leading from the reservoir. From this valve a pipe extended under the tender and was connected by flexible hose sections to a similar pipe under the entire length of each car. Branch pipes led to "brake-cylinders," and the stems of the pistons in the latter were connected with the brake-levers on the cars. Upon opening the engineer's valve, air pressure passed to these cylinders, pushing the pistons backward, operating the brake-levers and forcing the brake-shoes against the wheels. It was found that the operation of this apparatus was too slow, and was attended by danger of collision in case one part of the train became detached.

About 1872 or '73 Westinghouse produced an "automatic brake" which embodied the addition of an auxiliary reservoir and a triple-valve device to each car. Each reservoir was of sufficient capacity for at least one full application of the brakes, thus providing for automatic action in the event of accident. The operation of this brake was radically different from that of the "plain-brake." In the former the compressed air was stored in the main reservoir until required for the application of brakes; in the latter the main and auxiliary reservoirs and trainpipe were always charged with compressed air at working pressure, to prevent the application of the brakes. The former system was operated by pressure from the main reservoir, while the latter system was operated by reduction of pressure in the train pipe. The result was automatic in action in case of accident, such as the bursting of hose or the train breaking in two. But this "automatic brake" was not capable of successful operation on long trains of freight cars. It was publicly tested in 1886, near Burlington, Iowa.

In 1885 the Railway Master Car-Builders' Association arranged for a series of experiments. Several companies entered into the competition, but none succeeded in stopping long trains of freight cars without violent and disastrous shocks. The trials were renewed in 1887, with five competing companies. The report of the committee was against all the competing devices, the committee concluding that air-brakes actuated by electricity were the only ones likely to be capable of successful operation on long trains of freight cars.

After these trials Mr. Westinghouse set himself to work to obviate the difficulties that had not yet been overcome, namely, to provide for uniformity in the application of the brakes and preventing shocks to the cars.

In the latter part of 1887 he succeeded in constructing a quick-action automatic brake, capable of being successfully applied to a train of 50 cars, and operative under all conditions of practical railway service. The requirements with which he then for the first time successfully complied were: (1) The regulation of the force to be applied to the brake-shoes so as to secure all necessary graduations, from the mere slackening of speed to the service-stop, and from the service-stop to the emergency-stop. (2) The automatic operation of the brakes in case of accident. (3) The practical simultaneous operation of the brakes on each car, so that, in long trains of freight cars, shocks might be avoided. (4) The control of all these

operations by the engineer; and (5) Certainty of operation under all conditions.

This has been judicially determined to be "the first system which practically solved the problem of immediate stoppage of a long freight train in time of danger, in connection with and supplemental to 'train-brake graduations.'"

Less than ten years ago this matter was still problematical. To-day nearly every railroad in the United States and Europe is equipped with brakes operated by compressed air.

CARS TO RUN BY AIR.

(*Chicago Times-Herald.*)

Street cars propelled by compressed air will soon appear in Chicago. The continual rattle and clanging of cable cars, the roaring and buzzing of electric cars and the clatter of iron-shod hoofs may be heard no more if the newcomers prove practicable. For cars with compressed air motors are said to be the best for travel if they can be made as serviceable as other means of transportation.

Within four weeks two cars equipped with these motors will be given a trial on the tracks of the General Street Railway Company. Those interested in the new system say a trial will mean adoption, for their faith in compressed air motors is unbounded. With adoption, they say, the death-knell of trolley and cable cars will be sounded.

ALREADY A SUCCESS.

The compressed air company has now everything that it needs in the way of compressors, and the two cars which are about to be shipped from Rome, N. Y., to Chicago, it is claimed, are practical and perfect illustrations that the day of independent motors has come. One of the cars has been running daily in Rome for eight months, and during that time no breakdown has occurred.

One of the stockholders of the company said recently that seamless tubes, filled with compressed air, were stored under the seats of the cars. These tubes were connected by piping with an engine underneath the cars. Before reaching the engine the air passed over a hot water tank, by contact with which it was heated. In the coldest weather a little vapor, it is said, escapes from the engine, this being the only evidence of the force at work.

NO FEAR OF EXPLOSION.

The cars to be brought to Chicago are "double enders," like the electric cars, and the motormen will change from one platform to another when the end of a run is reached. Experiments have demonstrated that nothing is to be feared from an explosion if any ever occurs. The cars will have storage capacity for enough power to drive them 17 miles with a single charge of compressed air. If trailers are used, compressed air tanks may be stored under the seats, and an indefinite distance may be covered. Almost any speed, it is said, may be attained, and the cost of operating is declared to be from 30 to 40 per cent. cheaper than by electricity or cable.

Some of the other reasons which the promoters give that compressed air is to drive cable and electricity as street car motor powers out of Chicago are: No poles, overhead wires, cables, pipes or conduits; no electrolysis of water and gas pipes by escaping currents; no obstructions in the way of the work of the fire department; no tearing up streets for underground construction; no fatal accidents from live wires; no possible stalling on railroad crossings in front of an approaching train, and no obstructing of the running of cars in time of riot by tampering with the sources or conductors of power.

HERSENT, the French engineer, says that if proper precautions are taken when men leave the caisson, he sees no reason why a depth of foundation of 164 feet should not be reached with compressed air.